Microcontact structure for neuroprostheses for implantation on nerve tissue and method therefor

THE FIELD OF THE INVENTION

The invention relates to an implantable microcontact structure for neuroprostheses for treating functional disorders of the nervous system for the purpose of reversible anchorage on nerve tissue.

BACKGROUND

Several microcontact structures for partly implanted neuroprostheses are known whose spatial microcontact arrangement is fixed by a rigid, preshaped area (see for example in US-A-5,215,088).

Several microcontact structures for partially implanted neuroprostheses are known whose spatial microcontact arrangement is fixed by a partly elastic, flexible, preshaped area and that can alter as a result of the type of implant attachment and also as a result of passive matching to the tissue shape in the implant area (see for example DE-A-4424753).

The production of such a microcontact structure is disclosed (for example) in "Flexible, polyimide-based neural interfaces" Stieglitz *et al*, J-U. Proceedings of the Seventh International Conference on Microelectronics for Neural, Fuzzy and Bio-Inspired Systems and in IEEE Comput. Soc. 1999, pp. 112-19. Los Alamitos, CA, USA.

A disadvantage of the known microcontact structures is that no devices and methods are provided for explantation of the microcontact structure.

Furthermore, known microcontact structures do not have mechanisms that carry out matching of the microcontact structure to the shape of the tissue to be contacted. It is therefore not possible to minimise the spacing between the microelectrodes and the neurones to be stimulated in the nerve tissue.

A further disadvantage of known microcontact structures is that they do not have the possibility of spontaneous attachment of the microcontact structure to the nerve tissue.

A disadvantage of the currently designed or available microcontact structures for epiretinal optic prostheses is that they lack features that permit incorporation in the eye in spatially compressed shape and complicated surgical techniques are therefore necessary. This difficulty will heighten in the future as the spatial dimensions of the microcontact structures become greater with an increasing number of contacts.

Furthermore, the available microcontact structures for epiretinal optic prostheses are incapable of covering the neurones of the retina that connect the region of sharpest vision with a high microcontact density since such neurones are situated in so-called parafoveal cell craters that are distinguished by a spatial crater structure.

OBJECTS OF THE INVENTION

The object of the present invention is to eliminate these disadvantages and to provide a microcontact structure that can be introduced in compressed form into the body and can be reversibly anchored on the nerve tissue.

SUMMARY OF THE INVENTION

Thus viewed from one aspect the present invention provides an implantable microcontact structure for neuroprostheses having a number of contact elements that are formed on at least one two-dimensional carrier, wherein the carrier has at least two regions that are movable relative to one another and that can assume at least two preferred positions being a basic position and an operating position.

The microcontact structure ensures a good contact or active connection to the nerve tissue since the implanted microcontact structure comprises subareas that are movable relative to one another that can be brought into at least two permanent preferred positions relative to one another. Moreover during implantation, the subareas can be brought into a desired position for the purpose of mechanical anchorage to the nerve tissue to be contacted and can (during explantation) be brought out of one desired position into another to release the anchorage.

Advantageous designs of the spatially adaptive microcontact structure and the associated methods are shown on the basis of Figures 1 to 4.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

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~~An advantageous device comprising a spatially adaptive microcontact structure for neuroprostheses for implantation at nerve tissue embodies the feature that the microcontact structure can be produced as a planar, two-dimensional structure using current methods for producing microcontact structures (for example on a silicon, silicone or polyimide base (see Figures 1-4)). It can be folded or rolled very compactly in a second step for transportation purposes and can not only be unfolded planarly in a third step but may~~

be folded or rolled into a third dimension (see Figures 1-3) so that a three-dimensional structure is produced.

An advantageous design of the microcontact structure embodies the feature that it is connected to further modules of the neuroprosthesis via signal paths.

An advantageous microcontact structure embodies the feature that it is used for implantation at mammalian muscle tissue or at blood vessels or at body organs (such as for example liver, spleen, lung or kidney) and produces a unidirectional or bidirectional active connection locally at such a point.

An advantageous microcontact structure embodies the feature that on the side adjacent to the nerve tissue after implantation, are provided projecting structures (for example in the form of microelectrodes, sensors, cannulas or nails) that are essential for the mechanical anchorage of the microcontact structure.

For the purpose of conversion to a transportation position by folding, rolling or nesting of the mutually connected parts, an advantageous microcontact structure embodies the feature that segments or islands out of a preset planar basic position, spring elements (such as for example spiral springs or helical springs) and elastic elements (such as for example cushion-like microcontact structures filled with gases or liquids and enclosed with an elastic material and also for example porous, sponge-like microcontact structures) are clamped in such a way that automatic restoration of the basic position is mainly prevented by a transport lock.

An advantageous transport lock embodies the feature that the microcontact structure is held in the transportation

position by a clamp that absorbs the forces or an envelope or pinning.

An advantageous operation of the transport lock embodies the feature that the transport lock is released at the implantation point by using a suitable tool so that conversion from the transportation to the basic position takes place as a controlled movement. In the case of a clamp, envelope or pin, this preferably takes place such that the forces are first absorbed by (for example) a tongue-like tool, the transport lock is then removed with a further tool and the conversion to the basic position is then controlled with the aid of the tongue-like tool.

In the case of an envelope brought about by temperature reduction or by a movement blockade produced by icing, the conversion from a locked transportation position to a basic position preferably takes place such that the mobility of its parts is restored by a controlled heat supply using a suitably shaped and controllable local heat source either as a separate tool or as an integrated element of the microcontact structure after positioning the microcontact structure at the implantation point.

In the case of an envelope brought about by temperature reduction or a movement blockade produced by icing, an advantageous microcontact structure embodies the feature that the reconversion from an operating position to a basic position is preferably brought about in that the mobility of its parts is blocked by controlled heat removal using a suitably shaped and controllable local cold source (for example, a Peltier element) as an integrated element of the microcontact structure for the purpose of re-explantation.

A further advantageous device of a spatially adaptive microcontact structure embodies the feature that the structure (which is transported locked in a folded-up state and implanted) unfolds itself on removing the lock as a result of material properties and thereby assumes a previously impressed three-dimensional structure.

A further advantageous device of a spatially adaptive microcontact structure embodies the feature (as a result of the self-unfolding) that the structure assumes a shape in which it can engage with the tissue as a result of raised microcontacts (see Figure 3).

For the purpose of explantation, a further advantageous device of a spatially adaptive microcontact structure embodies the feature that the shortened connections on the structure can be separated and the structure brings itself back (as a result of material properties) into a planar state in which the engagements with the tissue are released.

A further advantageous device of a spatially adaptive microcontact structure embodies the feature that the structure does not require any further attachment for the purpose of positionally stable implantation as a result of the engagement.

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~~A further advantageous method embodies the feature that the microcontact structure is based on a substrate of multilayer construction that has so-called memory properties with regard to the spatial arrangement of the microcontact structure. Figure 4 shows a section through an advantageous 4-layer microcontact structure in which the active connection between the microcontact structure and the nerve tissue is brought about by electrical stimulation. The layer adjacent to the nerve tissue to be~~

stimulated is composed of the polymer P1 (polyimide) and contains penetrating electrodes made of the metal M (platinum) which forms the adjoining layer. There follows a further layer of the polymer P1 and a layer of the polymer P2 (polyurethane). The polymer P2 has the property of thermal expansion relative to P1 and the absorption of infrared radiation (IR) so that a defined volume expansion is brought about by irradiation with IR light.

In this way, the microcontact film is deformed at defined points by focused irradiation and matched to the nerve tissue. Furthermore, the polymer P2 has the property of carrying out structural transitions during electromagnetic irradiation from the ultraviolet wavelength range, said transitions resulting in contraction of the material. As a result, the deformation previously achieved by IR light or the opposite deformation is compensated for by means of focused UV treatment so that detachment of the microcontact structure from the nerve tissue takes place. In this way, the re-explantation of the microcontact film is initiated.